TRILLION TREES

WCS WWF BirdLife INTERNATIONAL

Defining the Real Cost of Restoring Forests

Practical steps towards improving cost estimates

A Trillion Trees White Paper

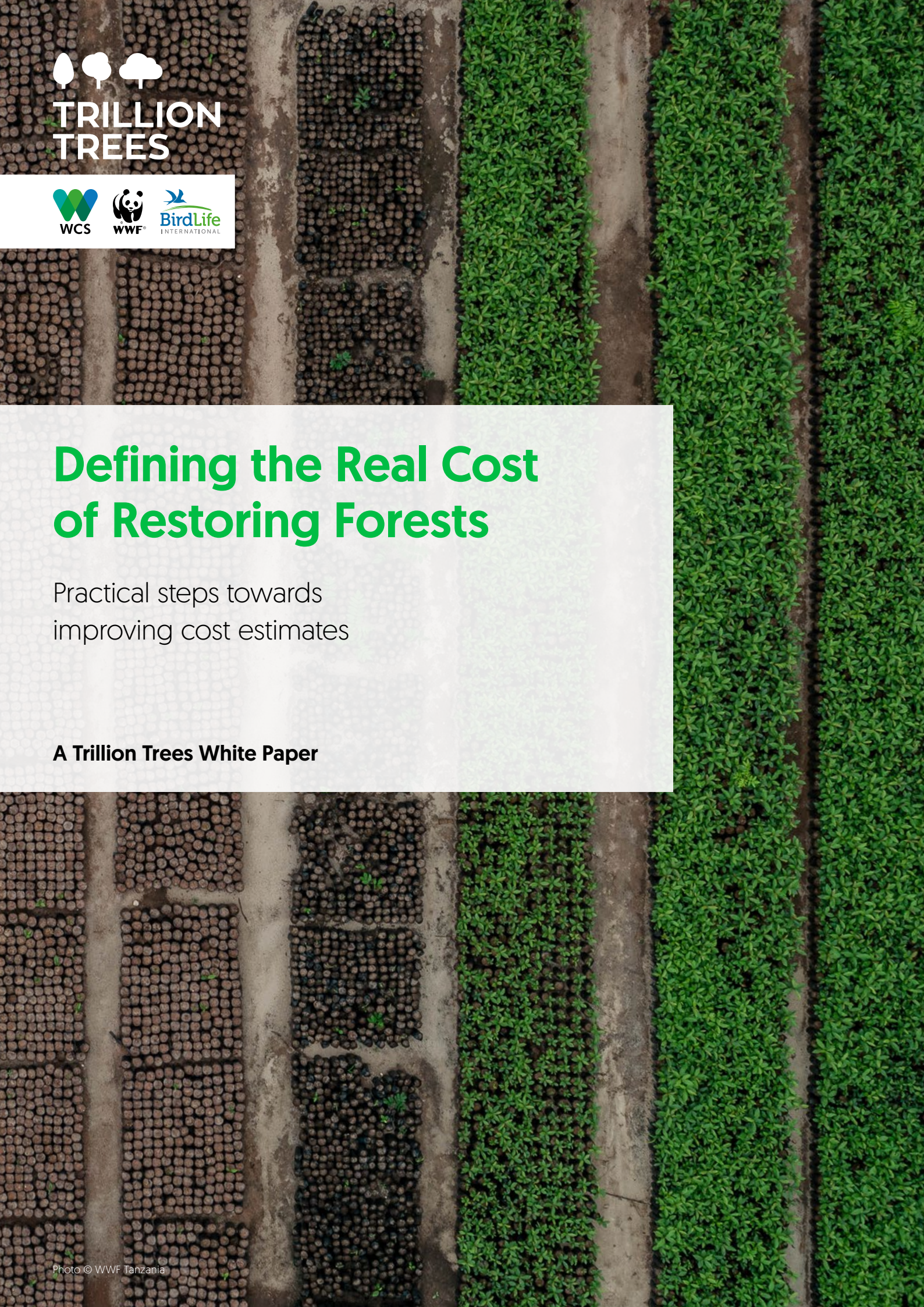

Photo © WWF Tanzania

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Context: the urgent need for forests and for quality, sustainable restoration

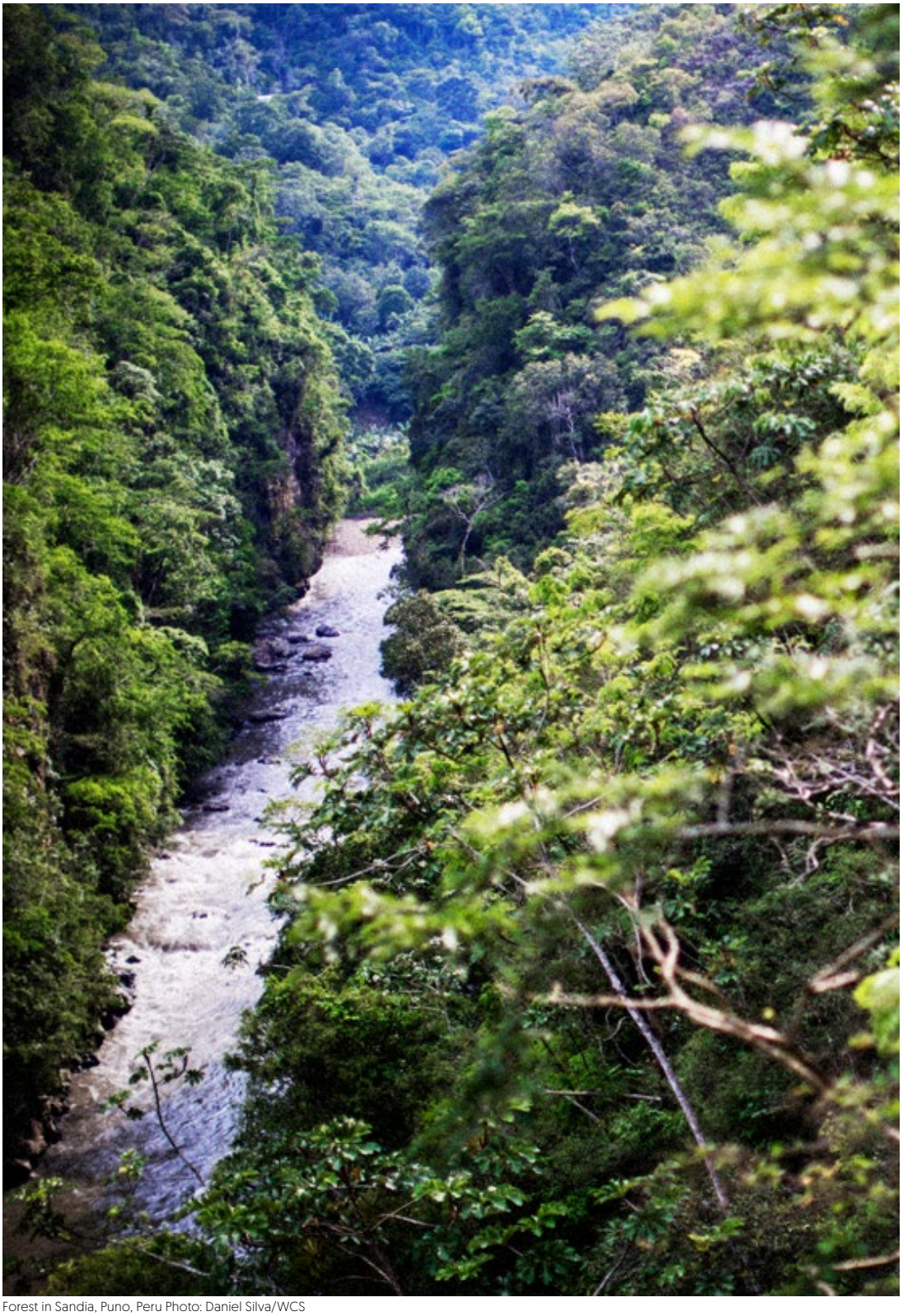
As the recent IPCC publications[1,2,3] put into stark relief, the world faces an increasingly severe climate emergency, with limited time to correct the course away from looming climatic tipping points. Human activity that is heating the planet has caused biodiversity to crash, with millions of species at risk of extinction. The direct impacts of climate change, such as extreme droughts, flooding events, and increasing fire intensity and severity are making some landscapes already unlivable and promoting human suffering, food insecurity, and disease.

Addressing these challenges and moving towards sustainability will require drastic reductions in greenhouse gas emissions within the next decade. At the same time, the evidence is equally clear that the global community must also safeguard and **restore** nature, especially the remaining, relatively-intact ecosystems that offer one of the most obvious and immediate options to build climate resilience.[4]

To this end, forests took centre stage at the opening of the COP26 UN Climate Summit, when 141 countries committed to ending and reversing forest loss and degradation by 2030. The 'Glasgow Leaders' Declaration on Forests and Land Use'[5] represents the culmination of many other commitments in recent years, including the Bonn Challenge, a global pledge to bring 350 million hectares of degraded and deforested forest landscapes into restoration; the UN Decade on Ecosystem Restoration, which launched in 2020 to prevent, halt, and reverse the degradation of ecosystems; and the '#trilliontrees' movement, an effort to conserve and grow 1 trillion trees worldwide. Calling for strengthened efforts to conserve forests and other terrestrial ecosystems and accelerate their restoration, the Glasgow Declaration also came with commitments of $12 billion in public funds for forests and more than $7 billion in private investments.[6]

Increasing media coverage of **trees** as a natural climate solution has created momentum. Tree planting is a tangible action that offers everyone a chance to engage in climate action. Enthusiasm for planting trees has grown rapidly around the globe. Over the past few years, many established tree-planting organizations doubled or even tripled their level of activity. The total number of organizations has also exploded, with new players continually entering the arena.[7] Corporate involvement has grown fast, along with increasing engagement from organizations seeking to guide policy, and track outcomes.[8] Tree planting offers have brought in millions of dollars of financing from philanthropic donors, individuals, and businesses.

However, the focus on individual trees has commodified the act of tree planting (marketing offers abound for "$1 per tree" or less) and led to organisations competing to plant more trees for less money. This competition has tended to obscure the desired outcome: that of effective ecosystem restoration that delivers lasting benefits for people, nature and the climate. As Bethanie Walder, Executive Director of the Society for Ecological Restoration (SER), states, restoration should deliver "net ecological improvement."[9]



Forest in Sandia, Puno, Peru Photo: Daniel Silva/WCS

The challenge: finance for restoration must focus on *quality*

Trillion Trees welcomes the growing global interest in trees as a climate solution. However, with more use of tree planting in corporate climate pledges, greater focus on effective ecosystem restoration is needed. This means more transparency on how money is being spent and what climate, biodiversity, and local community benefits are being produced. Claims about the benefits of tree planting must be substantiated, and investments must be shown to deliver sustainable results that benefit multiple stakeholders and increase biodiversity. Trillion Trees encourages the shift to focus on tree **growing**, as opposed to tree **planting** – as long-term success hinges on the trees' lifelong journey[10] – and to forest landscape restoration (FLR) as the desired goal of tree growing initiatives.

Creating the perception that forest landscape restoration can be achieved for $1 per tree risks undermining the success of a very promising restoration movement. It creates pressure on projects to overlook the real costs of working collaboratively and effectively with local communities, of choosing the right trees for the right places, and of maintaining restoration sites to ensure long-term success where trees survive for decades to provide the benefits claimed.

While it may be possible to raise a seedling for $1, restoring a forest landscape requires a greater level of investment if it is to deliver human, climate and biodiversity benefits. In practice, organizations marketing "$1 per tree" often need to support their projects with additional grants from governments and/or in-kind contributions, meaning the true costs exceed those used in promotions. Additional funds are needed to cover the real costs of good management and monitoring, and if additional funds are not secured, projects are unlikely to deliver the promised benefits.

> "It's not about **planting** trees, it's about their **survival**. For that, you need to address the causes of deforestation: if you do not provide alternative sources of income to the communities, chances are the trees will continue to be cut. Also you need science to help select the right trees and adapt your methods to the local conditions.
>
> So our advice when companies shop around for a great partnership, is to always enquire about the part of the budget dedicated to **forestry** activities as well as for **livelihoods** and for **science**. Only then can you be sure the trees will have a real long term impact for People and the Planet."
>
> **Marie-Noelle Keijzer, CEO, WeForest**

Furthermore, if projects are obliged to combine funds, the results may be double or triple counted, undermining sponsor's claims of impact.Under-budgeted and poorly-implemented projects are more likely to fail, leading to an overestimate of the area restored,[11] non-realisation of climate targets, and a significant amount of money wasted. In some cases, the conditions at planting sites could be worse than before trees were planted. Mangrove restoration, which features prominently in many corporate tree planting efforts, can easily fail if tree species are not well suited for the planting sites.[12] A race for producing cheap trees in large numbers is also likely to result in the planting of monocultures, which deliver limited biodiversity benefits,[13] or the choice of inappropriate land. The ecological consequences of replacing natural grasslands with planted trees have been well documented.[14] Poorly designed tree planting initiatives can shift the structure and composition of forests in undesirable ways,[15] and may result in local reductions in water availability in streams and rivers.[16, 17]

Forest restoration is necessary—now and at scale. But restoration actions must aim for high standards of climate, social and ecological benefit.[18,19] To deliver these benefits, they must be properly resourced.

A note on carbon pricing for trees in voluntary carbon markets

The voluntary carbon market space has begun to recognize the true costs of effective forest restoration. Since VCS/CCB rules for carbon crediting require projects to demonstrate long term climate, community and biodiversity benefits, there is a recognition that just planting a tree isn't enough. In general, $1/tree is equivalent to a carbon price of $5/tonne CO2, which few investors would believe is sufficient to establish and sustain a carbon removals project that can avoid leakage, deliver clear additionality and permanence. The global average carbon sequestration rate for recovering natural forest is around 10.37 kg CO2 per tree per year,[33] which means one tree sequesters 200 Kg CO2 over 20 years (0.2 tCO2). If 1tCO2 is valued at $5, then 0.2 tCO2 = $1.00 in carbon money.)

However, $5 per tonne is far below most estimates of what is considered adequate to generate emissions reductions from nature-based approaches. Brancalion et al. (2020) estimated the cost of carbon sequestration in recovering secondary forests of Brazil's Atlantic Forest at $66/tonne.[34] A 2018 study using data from Cambodia, found that when considering opportunity costs of land (timber and rubber profits), transactions costs for carbon certification, and implementation costs, just keeping a forest standing required $30–$51 per tCO2 to break even on costs. A 2017 report by the High-Level Commission on Carbon Prices concluded that the carbon price level consistent with achieving the Paris temperature target, which the world is now on track to surpass, is at least $50-100 per tCO2 by 2030 with a supportive policy environment in place.[35, 36] This range is regarded by many practitioners as a better estimate of the true cost of delivering emissions reductions.

Thus, $1 per tree significantly under-estimates the actual cost of delivering carbon removals through forest restoration. A project funded at that level is unlikely to have considered the full implications of what is needed to ensure the permanence of the restored forest or its long-term potential for sequestration.

Guiding Principles of Forest Landscape Restoration

- **Focus on landscapes**

  Work across entire landscapes, not individual sites, representing mosaics of interacting land uses and management practices under various tenure and governance systems. It is at this scale that ecological, social and economic priorities can be balanced.

- **Maintain and enhance natural ecosystems within landscapes**

  Enhance the conservation, recovery, and sustainable management of forests and other ecosystems. Project should not lead to the conversion or destruction of natural forests or other ecosystems.

- **Engage stakeholders and support participatory governance**

  Actively engage stakeholders at different scales, including vulnerable groups, in planning and decision-making regarding land use, restoration goals and strategies, implementation methods, benefit sharing, monitoring and review processes.

- **Tailor to the local context using a variety of approaches**

  Use a variety of approaches that are adapted to the local social, cultural, economic and ecological values, needs, and landscape history. It draws on latest science and best practice, and traditional and indigenous knowledge, and applies that information in the context of local capacities and existing or new governance structures.

- **Restore multiple functions for multiple benefits**

  Aim to restore multiple ecological, social and economic functions across a landscape and generate a range of ecosystem goods and services that benefit multiple stakeholder groups.

- **Manage adaptively for long-term resilience**

  Seek to enhance the resilience of the landscape and its stakeholders over the medium and long-term. Restoration approaches should enhance species and genetic diversity and be adjusted over time to reflect changes in climate and other environmental conditions, knowledge, capacities, stakeholder needs, and societal values. As restoration progresses, information from monitoring activities, research, and stakeholder guidance should be integrated into management plans.

Source: https://infoflr.org/what-flr

Solution pathways: addressing the need for better cost estimates

Research now underway at Trillion Trees—a joint venture for forests between BirdLife International, the Wildlife Conservation Society (WCS) and the World Wildlife Fund for Nature (WWF)—aims to arrive at a realistic calculation of the investment needed to deliver high-quality sustainable forest restoration. Our definition of quality is grounded in globally-accepted Forest and Landscape Restoration principles. In this paper, we describe what best practices look like and why we need more complete cost considerations if practitioners are to deliver effective action.

Up-front and continued investment in **effective and long-lasting** restoration is essential to the success of the forest restoration movement. For this movement to be effective, we need a common understanding of what constitutes a good quality investment for good quality outcomes (e.g., scalability, accountability) and benefits (e.g., climate mitigation and adaptation, biodiversity conservation, local livelihoods)[20] in Forest (and) Landscape Restoration and more realistic assessments of what it costs to deliver in practice.

A note on restoration estimates in the literature

Pricing per tree may serve a purpose for organizations to attract individual small donations, but estimating per hectare costs is a more widely-accepted standard of practice. (Typically, planting a hectare in a tropical region would involve about 1000 trees[37], but number of trees/per hectare vary between projects and regions.) Estimates from the literature span a wide range—from $14 at a bare minimum up to $1,400/ha for natural regeneration and $34,000/ha for large scale, active restoration.[38,39] A driving variable is the type of restoration activity (or activities), such as natural regeneration, agroforestry, or other planting that can require seedling collection, nursery propagation, and clearing vegetation around trees for a few years. Labor is also a key factor, with cost notably higher in the Global North and variation across countries in the Global South.

In the short-term, 'trees on farms' approaches may be lower cost over time because farmers may contribute their labor to planting and aftercare, and then derive longer-term economic benefits such as fuelwood and timber. Restoring natural forest, in contrast, may be more expensive if the objective is ecological restoration and no future economic use, such as timber harvest, is envisaged. Instead, projects restoring forests for ecological objectives will need to cover the costs of the protection of those restored areas from the very pressures that resulted in their initial degradation.

If the opportunity cost of land is considered in these cases, this will dramatically increase the project cost. Particularly in parts of Africa, allowing degraded forests to regenerate naturally and farmer-managed natural regeneration has been estimated to cost as little as $14–153 per hectare where farmers provide unpaid labour.[11,40] Recent research suggests a global average of $2328/ha for forest restoration; in Brazil's Atlantic Forest, for example, estimated costs are as low as $1,250/ha for natural regeneration that only requires fencing and up to $3,750/ha for tree planting and fencing combined.[36,41] However, these costs generally refer to establishment only and do not include longer-term management expenses.

Solution pathways: defining good quality restoration

What is quality? Considering the growing body of knowledge on what constitutes best practice

Forest restoration aims to regain ecological functionality and enhance human well-being in deforested or degraded landscapes.[21] Launched in 2003 by WWF, IUCN and the UK Forestry Commission, the Global Partnership on Forest and Landscape Restoration was established by a group of conservation organisations and governments to guide the development of the FLR approach and ensure that practitioners steer towards better practices. Their "Principles of FLR" (2018) provide a flexible framework that encourages projects to increase the level of participation in planning and to adopt adaptive management practices (via impact monitoring, for example).

Other guides and standards have followed,[22, 23, 24] including those led by the Food and Agriculture Organization (FAO),[25] which emerged from discussions within the Taskforce on Best Practices, convened under the auspices of the UN Decade on Ecosystem Restoration. The Taskforce also has a forthcoming compilation of standards of practice for ecosystem restoration. Trillion Trees and Nature4Climate have also published their own investment guides (i.e., Reforest Better, Guide to Investing in Forest Restoration); both highlight the need for forest restoration projects to deliver positive outcomes for climate, people, and biodiversity. Scientists at the Royal Botanic Gardens Kew and Botanic Gardens International have published their 10 Golden Rules for Reforestation.[26]

Community Forest Association tree planting in Mt. Kenya. Photo: Nature Kenya

Looking across these various standard setting initiatives, a clear consensus on what constitutes best practices is now emerging:

- Projects promoting forest landscape restoration should ensure the local context and local priorities are considered, and in-depth consultation with local stakeholders has been undertaken **in the design of and throughout** restoration interventions.

- Projects should add to the **protection of standing forests** and find ways to address the drivers of land use change, so that they do not continue to undermine restoration efforts.

- In the choice of interventions, restoration efforts should prioritize the use of **native species** to restore natural habitat.

- Planting trees may not be the best or most cost-effective solution in areas where **natural regrowth** is possible.

- Projects must also consider the **local economy** and provide ways for local people to profit or benefit from restoration efforts.

- Crucially, projects should ensure that restoration efforts are backed up with **systematic monitoring** to enable the measurement of success and facilitate review and lesson learning. Monitoring also underpins the demonstration of compliance with standards, and it is becoming increasingly important to demonstrate transparency and accountability in the use of funds.

- **Plan long-term for growing trees** rather than planning for planting or the first couple of years.

Solution pathways: identifying the cost considerations

The emerging principles and standards that facilitate good practice help to indicate major cost categories that should structure how project managers and investors address costs. To enable proponents to assign costs to elements that lead to high quality restoration initiatives, we suggest **5 cost considerations** for use in budgeting for forest restoration interventions. Taking these considerations and their various components into account should ensure project budgets better reflect the true costs of implementing good practice and result in better global estimates and restoration outcomes.

1. Account for planning: Clearly define the project objectives and intervention strategies.

The first critical step for improving cost estimation is to clearly define the project objectives and appropriate intervention strategies. There are many potential reasons for regrowing trees, such as conserving biodiversity, enhancing ecosystem processes, counteracting climate change, provisioning income and goods, conserving cultural values, or reconnecting with nature, and/or complying with legislation.[27] Each objective may inform a different approach, and each approach will likely have different costs. Projects, especially those that take a landscape approach (as recommended by the FLR Principles) may include multiple intervention types, such as assisted natural regeneration combined with direct plantings. Some projects will aim to support the reforestation of public land, whereas others may focus on approaches such as Farmer Managed Natural Regeneration (FMNR), or agroforestry on private farmlands. The costs of these intervention strategies may differ, so they may need to be separated out and budgeted separately. While Trillion Trees restoration activities largely occur on degraded public or protected lands, considering the opportunity cost of the land on private or communally-owned lands can add further complexity, and may significantly increase costs.

Example 1. Promotion of woodlots in Tanzania
(cost $2/tree; $1600/ha).

This project, which was run by WCS Tanzania, seeks to provide farmers with sustainable sources of fuel wood, and to diminish their reliance on natural forest for timber and charcoal. The project has promoted the establishment of fast-growing trees on private farmland. Because farmers cover much of the establishment cost themselves and expect to derive an economic benefit from the trees in future, in the form of fuel wood and marketable timber, the direct project costs are relatively modest. The project covers the cost of seedling production and distribution and the mapping and monitoring of planted sites. While the project has little direct biodiversity benefit in the planted areas, the collective effect of reduced pressure on natural forest reserves will help the natural forest to recover. Evidence suggests that the overall programme of which this tree planting initiative is a part, has successfully reduced human pressure on the Mount Rungwe Nature Reserve.[42]

2. Account for local participation and privilege local knowledge

Projects should privilege local knowledge and practices, ensure local participation, and ensure local communities directly benefit. Engagement and local participation require time and resources before any trees are planted, to ensure that Indigenous peoples and local communities have given their free, prior, and informed consent (FPIC), and are actively involved in planning, decision-making, and implementation.
Land ownership and use rights must be carefully clarified and respected, which can take time and contribute significantly to project costs.

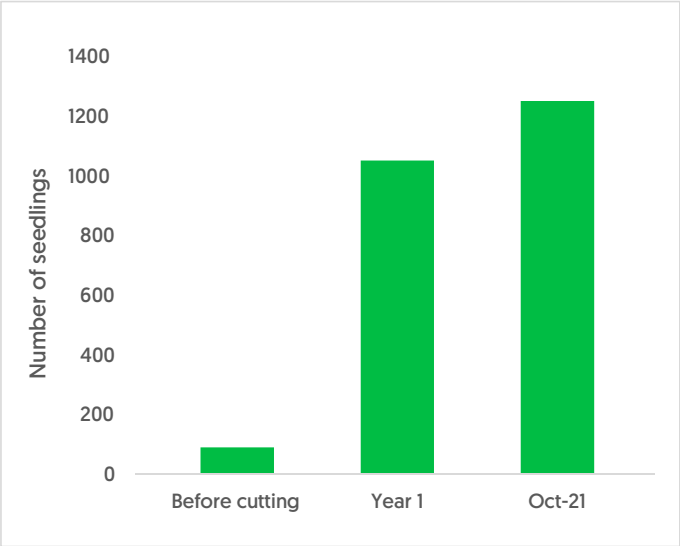


Figure 1. Monitoring results showing the increase in seedling numbers in sample plots over the 2 years following fern cutting, which began in October 2019. (Unpublished data: WCS Rwanda)

Example 2. Restoring natural forest in Nyungwe, Rwanda
(cost $3.75/tree; $3000/ha).

This project was jointly implemented by Rwanda Development Board and WCS from 2010 to 2021. It involved the promotion of natural regeneration in fire-damaged areas of Nyungwe National Park. Burned areas were colonized by ferns, which prevented the regrowth of tree seedlings. By manually removing the ferns it is possible to stimulate the regeneration of tree seeds that are still present in the soil seedbank. Most of the project sites are remote, in difficult terrain with limited potential for vehicle access. The project covers all labour cost for fern clearance, and multiple maintenance visits (2x per year for 3 years). However, as the project relies on natural regeneration, no purchase or transport of seedlings is required. The opportunity cost of land is zero as the project sites are all within the national park, which is an integrally protected area. Experience has shown that the approach is successful, but the constraints of donor funding have meant only around 100 ha has been successfully restored so far.

Figure 2. Condition of degraded areas in Nyungwe National Park before restoration interventions (Photo: WCS Rwanda)

Figure 3. Fern clearing in Nyungwe National Park to permit natural regeneration of forest trees. (Photo: WCS Rwanda)

Figure 4. Seedlings of native trees regenerating from the seedbank after fern clearing. (Photo: WCS Rwanda)

3. Account for different interventions within the same landscape.

Projects may promote different interventions within the same landscape. Each intervention will have different cost components. For example, many projects support farmers to plant trees that will offer a future economic return (for example as timber or fuelwood). The same project may also be supporting the replanting of natural forest where no future timber harvesting or economic use is expected. Both interventions contribute to the landscape goals, but will have different cost structures. Farmers, who will derive economic benefits from planting woodlots, may be prepared to contribute their own labour during woodlot establishment, lowering the project's up-front cost per tree.

Relatedly, seedlings for common commercial tree species may be cheaper to produce than seedlings of rare natural forest trees. As a result, projects pursuing natural forest restoration with native forest species, where there is no expectation of timber harvesting, tend to have much higher overall costs. Approaches such as applied nucleation, mostly based upon planting tree islands, can reduce those costs or make facilitated regeneration more cost-effective.[28, 29]

Where projects are pursuing multiple interventions under a landscape approach, these different cost parameters need to be itemized for each intervention. Estimates of overall project cost per tree or per hectare will need to reflect these differences and the proportion of each intervention within the landscape.

Preparing seedlings in the Southern Highlands, Tanzania. Photo: WCS Tanzania

Beekeeping in Pugu Hills Forest Reserve, Tanzania. Photo: WWF Tanzania

4. Account for site preparation and ongoing maintenance.

These costs depend on local site conditions and the restoration interventions applied, and are additional to planting or implementation costs. Planted areas will likely need weeding and protection from grazing animals or fire. Climate variability and unexpected events, such as drought or flooding that can affect seed germination or seedling establishment may increase the cost of maintenance.[30] Some form of maintenance is usually needed for at least a couple of years and some projects may require maintenance for several years. In tropical conditions, weeds (and fire) may need to be controlled until planted trees can establish a canopy and shade out competition. In arid or nutrient poor sites, irrigation or fertilization might be required initially. If these activities need to be conducted over a period of years, projects will need to 'front-load' these costs into their costs per tree.

Young Polylepis pepei tagged for monitoring Bolivia. Photo: Asociación Armonía

5. Account for monitoring outcomes, assessing progress and developing local capacity.

Monitoring tree survival and growth, as well as other high priority objectives, is another important aspect contributing to cost that is often overlooked or under-resourced. A recent study of 174 tree planting organizations revealed, for example, revealed that only 5% mention measuring survival rate of plantings in their websites or reports.[31]

To reliably demonstrate impact, and validate claims of benefits, investment should be made to:

- monitor over time scales of years to build a rigorous case for impact or accurately capture challenges and failures;
- monitor and benchmark impacts on biodiversity and ecosystem services (e.g., benefits to livelihoods from reduced sedimentation of rivers; carbon sequestration) as well as tree counts;
- fund the development of technical expertise to adapt monitoring approaches to the local context, in order to ensure monitoring data is scientifically robust and meaningful.
- support local capacity to monitor and track outcomes, as well as engage in adaptive management of the project;
- accurately capture challenges and failures and guide corrective actions.

For organizations endeavoring to create lasting initiatives that result in a suite of benefits over decades, budgeting for effective monitoring and maintenance at the project onset is critical. Determining when the project is considered "completed" for the sake of estimating cost (e.g., 3 years, 5 years, 20 years) is a pervasive challenge. **NB: Some organizations report that effective monitoring can consume up to 20% of a project's budget.**

Building the case for assessing the true cost of forest restoration through gathering current practice and front-line experiences

The reflections above detail elements of restoration costing that, in our experience and research, we have found to be often overlooked or under-calculated. As we believe that this under-estimation risks undermining the realization of the ambitions of both Paris and Glasgow, Trillion Trees aims to categorise, document and quantify real-world data on costings from our partnership programming. Stretching across 60 countries, Trillion Trees partners have many forest conservation projects actively implementing FLR approaches, with detailed, on-the-ground knowledge of implementation costs. Based on the observations and insights detailed in this White Paper, Trillion Trees is engaged in leveraging this extensive network to assess the on-the-ground costs of forest restoration activities around the world. It is our hope that this project will provide a useful, data-led framework for restoration planning for projects around the world.

Critically endangered red ruffed lemur (*Varecia rubra*) in Makira, Madagascar. Photo: Andrew Kirkby/WCS

The five budget considerations for effective projects:

1. Account for planning: Clearly define the project objectives and appropriate intervention strategies.

- Consultation and planning with all relevant stakeholders

2. Account for local participation and privilege local knowledge

- Ensure Free Prior and Informed Consent (FPIC) can be demonstrated
- Active involvement of local stakeholders in planning, decision-making, coordination and implementation

3. Account for different interventions within the same landscape.

- Consider the differences between interventions that can produce economic returns, as well as those that are purely for biodiversity or carbon sequestration
- Recognize that working well with communities requires time and investment torespect and, where possible, integrate local knowledge

4. Account for site preparation and ongoing maintenance.

- Account for the aftercare and on-going management of planted/restored areas
- Account for the potential future climate risks (e.g., drought, fire)

5. Account for monitoring outcomes, assessing progress and developing local capacity

- Each target or objective should be supported with an approach to monitoring that considered short-term progress and long-term outcomes
- Indicators or metrics should be carefully selected and tailored to project objectives and outcomes,[33] including local capacity-building

Steps to deliver a data-led framework for assessing the full cost of forest restoration

Step 1: Develop a budgeting framework

We have developed a project level budgeting framework, based on the five components of successful forest restoration described above. This budgeting framework asks projects to budget different interventions, while accounting for the necessary management and oversight, maintenance and monitoring costs. The framework allows projects to estimate implementation costs over several years (up to 10) to allow more accurate accounting for longer term costs (such as monitoring) and consideration of the necessary staff time inputs over these time scales.

Step 2: Collect data from a range of examples

The budget template has been shared with a sample of project managers who are facilitating Trillion Trees projects around the world. The cost data from each project will be compiled in an anonymized database of projects by country.

The comparison of project level budgets across different types of intervention in different countries will allow Trillion Trees to draw conclusions about the relative costs of different types of FLR intervention, the proportion of costs assigned to the different categories of activity, the proportion of staff costs to material costs, the and the spread of costs over time. Sampling projects of different sizes will also give insights into economy of scale effects.

The budgeting framework is also made available to other interested groups on request.

Step 3: Implement a consistent approach to true cost estimate

Until recently, with the introduction of a framework by The Economics of Ecosystem Restoration (TEER), a multi-partner initiative under the aegis of the U.N. Decade on Ecosystem Restoration, there has not been a consistent approach to assessing costs (or benefits) of ecosystem restoration.[11] Some methods of cost assessment report only the initial 'planting' costs, whereas others come close to a comprehensive costing approach. The high variability of project cost demonstrated by the existing literature (Table 1), as well as the lack of public information from projects implemented, makes the current reforestation movement a daunting scene for potential investors to enter.

Data from the Trillion Trees project database will ultimately provide cost data for the TEER global initiative, specifically their costing template tool which covers all types of ecological restoration (including forests). Costs data from Trillion Trees projects can be cross-referenced with TEER's costing codes to enable rapid integration of Trillion Trees data into the larger TEER system (Table 2).

Conclusions

Understanding the true cost of successful forest restoration is critical to arrive at a global recognition of the investment needed to ensure efforts are long-term, sustainable, and meaningfully contribute to achieving the ambitions of the Paris and Glasgow Agreements. Restoration of natural ecosystems is an ongoing and long-term commitment, requiring accurate estimations of key programme variables over multiple year and even decade scenarios. This is in contrast to many current funding mechanisms that tend towards the short term, mirror funding cycles, and focus on short-term metrics.

Trillion Trees asserts that accurately estimating the true cost of forest restoration also means being clear on the objectives of each planned tree growing or restoration programme. If projects are to result in multiple benefits for people, nature and the climate, and are not only targeting the number of trees in the ground regardless of survival, budgeting up front for the higher cost of delivery, community involvement, and monitoring is essential.

Our ongoing work to improve cost estimation aims to support the global trend towards more accountability and transparency for the resources invested in tree planting and forest restoration programmes.[32] It will closely examine the dynamics driving cost variables so that implementing organisations, governments, and those providing the funding can better understand how to deliver effective and impactful forest restoration.

Table 1: Cost data on intervention type, retrieved through a search of the literature on forest restoration in the tropics and subtropics (23 studies); table adapted from Bodin et al., 2021.

Intervention	Cost category (per ha)	Costs ($US/ha)
Assisted natural regeneration	Establishment	Range = $12–3,880
	Annual maintenance (years 1–5)	Range = $2–213
Agroforestry	Establishment (year 1)	Range = $125–1,240
	Annual maintenance (years 1–5)	Range = $5–720
Planted forests (for restoration)	Establishment (year 1)	Range = $105–25,830
	Annual maintenance (years 1–5)	Range = $167–2,421

Bodin, B., Garavaglia, V., Pingault, N., Ding, H., Wilson, S., Meybeck, A., Gitz, V., d'Andrea, S. and Besacier, C. (2021), A standard framework for assessing the costs and benefits of restoration: introducing The Economics of Ecosystem Restoration. Restor Ecol, 30: e13515. https://doi.org/10.1111/rec.13515

Table 2: Activity category variables within the TEER and Trillion Trees budgeting template for quantifying restoration intervention costs.

Activity Category	Description
Management & coordination (Consideration 1)	Project-level management and oversight.
Stakeholder engagement (Consideration 2)	Community-based process to engage relevant stakeholders for the purpose of defining and achieving outcomes, developing implementation strategy.
Preparation & Establishment (Consideration 3)	Refers to site work and preparation activities prior to establishment. May also include collection of seed and nursery set up costs. Restoration activities to establish the restored site. May include preparing the site for planting, and the planting of seedlings, or clearing weeds in the case of assisted natural regeneration.
Maintenance (Consideration 4)	Additional site care or community-support needed following planting, natural regeneration, or other establishment activities.
Monitoring (Consideration 5)	Observing, tracking, and assessing the progress and outcomes over a period of time; keeping under systematic review. Goals include accountability, adaptive management, short-term and long-term effectiveness.

https://www.fao.org/in-action/forest-landscape-restoration-mechanism/our-work/gl/teer/en/

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1 Climate Change 2021: The Physical Science Basis. https://www.ipcc.ch/report/ar6/wg1/

2 Climate Change 2022: Impacts, Adaptation and Vulnerability. https://www.ipcc.ch/report/ar6/wg2/

3 Climate Change 2022: Mitigation of Climate Change. https://www.ipcc.ch/report/ar6/wg3/

4 Global Commission on Adaptation. Adapt now: A global call for leadership on climate resilience. (2019). https://gca.org/reports/adapt-now-a-global-call-for-leadership-on-climate-resilience/. Last accessed 14 July 2021.

5 https://ukcop26.org/glasgow-leaders-declaration-on-forests-and-land-use/

6 Prime Minister's Office. (2 November 2021) Over 100 leaders make landmark pledge to end deforestation at COP26 [Press release]. https://www.gov.uk/government/news/over-100-leaders-make-landmark-pledge-to-end-deforestation-at-cop26

7 Martin, MP, Woodbury, DJ, Doroski, DA, Nagele, E, Storace, M, Cook-Patton, SC, and Ashton, MS (2021). People plant trees for utility more often than for biodiversity or carbon. *Biological Conservation*, 261, 109224.

8 WEF (2021) Investing in forests: the business case. Dahlberg and World Economic Forum. https://www3.weforum.org/docs/WEF_Investing_in_Forests_2021.pdf

9 Walder, A. Personal communication. 6 November 2020.

10 Duguma LA, Minang PA, Aynekulu BE, Nzyoka J , Bah, A, Jamnadass RH, and Carsan S (2020). From tree planting to tree growing: Rethinking ecosystem restoration through trees, ICRAF Working Paper No 304.

11 Bodin, B, Garavaglia, V, Pingault, N, Ding, H, Wilson, S, Meybeck, A, Gitz, V, d'Andrea, S, and Besacier, C (2021). A standard framework for assessing the costs and benefits of restoration: introducing The Economics of Ecosystem Restoration (TEER). *Restoration Ecology*, e13515.

12 https://www.bbc.co.uk/news/science-environment-61300708

13 Lewis, S and Wheeler, C (2019. Regenerate natural forests to store carbon. *Nature*, 568, 25-28.

14 Veldman, JW, Overbeck, GE, Negreiros, D, Mahy, G, Le Stradic, S, Wilson Fernandes, G, Durigan, G, Buisson, E, Putz, FE, and Bond, W (2015). Where Tree Planting and Forest Expansion are Bad for Biodiversity and Ecosystem Services, *BioScience*, 65(10), Pages 1011–1018.

15 Coleman, EA, Schultz, B, Ramprasad, V, Fischer, H, Rana, P, Filippi, AM, Güneralp, B, Ma, A, Rodriguez Solorzano, C, Guleria, V, Rana R, and Fleischman, F (2021). Limited effects of tree planting on forest canopy cover and rural livelihoods in Northern India. Nature Sustainability 4, 997–1004.

16 van Dijke, H, Herold, M, Mallick, K, Benedict, I, Machwitz, M, Schlerf, M, Pranindita, A, Theeuwen, JJE, Bastin, J, and Teuling, AJ. (2022) Shifts in regional water availability due to global tree restoration. *Nature Geoscience* 15, 363-368.

17 Fagan, ME, Kim, DH, Settle, W, Ferry, L, Drew, J, Carlson, H, Slaughter, J, Schaferbien, J, Tyukavina, A, Harris NL, Goldman, E, and Ordway, EM (2022). The expansion of tree plantations across tropical biomes. *Nature Sustainability*: 1-8.

[18] Osborne, T, Brock, S, Chazdon, R, Chomba, S, Garen, E, Gutierrez, V, Lave, R, Lefevre, M, and Sundberg, J (2021). The political ecology playbook for ecosystem restoration: Principles for effective, equitable, and transformative landscapes. *Global Environmental Change*, 70, 102320.

[19] Chazdon, R. L. (2013). Making tropical succession and landscape reforestation successful. J*ournal of Sustainable Forestry*, 32(7), 649-658.

[20] Chazdon, R and Brancalion, P (2019). Restoring forests as a means to many ends. *Science*, 365(6448), 24-25.

[21] Besseau, P, Graham, S, and Christophersen, T (Eds.) (2018). Restoring forests and landscapes: The key to a sustainable future. Global partnership on forest and landscape restoration.

[22] Brancalion, PHS and Holl, KD (2020). Guidance for successful tree planting initiatives. *Journal of Applied Ecology* 57(12): 2349-2361.

[23] Preferred by Nature. (2021). Ecosystem Restoration Field Verification Standard: Version 2.0 for Public Consultation. Last accessed online at: https://preferredbynature.org/sites/default/files/Preferred%20by%20Nature-Ecosystem-Restoration-Field-Verification-Standard-v%202.0.pdf

[24] Cairns, S, Dudley, N, Hall, C, Keeneleyside, K, and Stolton, S (2012). Ecological restoration for protected areas: principles, guidelines and best practices. *Best Practice Protected Area Guidelines Series*, (18).

[25] FAO (2021) UN Decade Principles for Ecosystem Restoration. UNEP, FAO, IUCN, CEM and SER.

[26] Di Sacco, A, Hardwick, KA, Blakesley, D, Brancalion, PHS, Breman, E, Cecilio Rebola, L, Chomba, S, Dixon, K, Elliott, S, Ruyonga, G, Shaw, K, Smith, P, Smith, RJ, and Antonelli, A (2020). Ten golden rules for reforestation to optimize carbon sequestration, biodiversity recovery and livelihood benefits. *Global Change Biology* 27, 1328–1348.

[27] Holl, KD (2020). Primer of ecological restoration. Washington, DC: Island Press.

[28] Holl, KD, Reid, JL, Cole, RJ, Oviedo-Brenes, F, Rosales, JA, and Zahawi, RA (2020). Applied nucleation facilitates tropical forest recovery: Lessons learned from a 15-year study. J*ournal of Applied Ecology* 57(12): 2316-2328.

[29] Wilson, SJ, Zahawi, R, Alexandre, NS, Celentano, D, Holl, KD, Sprenkle-Hyppolite, S, Reid, JL, and Werden, L (2021). Applied nucleation guide for tropical forests. Conservation International. https://www.conservation.org/docs/default-source/publication-pdfs/applied_nucleation_full_report_final.pdf

[30] Elias, PS, and Vieira, DLM (2020). Growth and survival of *Campinarana* seedlings subject to drought and flooding: implications for ecological restoration. Plant Ecology, 221(6), 459-474.

[31] Martin, MP, Woodbury, DJ, Doroski, DA, Nagele, E, Storace, M, Cook-Patton, SC, Pasternack, R and Ashton, MS (2021). People plant trees for utility more often than for biodiversity or carbon. *Biological Conservation*, 261, 109224.

[32] Holl, KD and Brancalion, PHS (2022). "Which of the plethora of tree-growing projects to support?" *One Earth* 5: 452-455.

[33] IUCN Global Emissions and Removals database. Info-FLR https://infoflr.org/

[34] Brancalion, PH, Guillemot, J, César, RG, Andrade, HS, Mendes, A, Sorrini, TB, Piccolo, MDC, Peluci, MC, Moreno, VDS, Colletta, G, and Chazdon, R. L. (2020). The cost of restoring carbon stocks in Brazil's Atlantic Forest. *Land Degradation & Development*. 32(2), 830-841

[35] United Nations Environment Programme. (2021). Emissions Gap Report 2021: The Heat Is On – A World of Climate Promises Not Yet Delivered – Executive Summary. Nairobi

[36] High-Level Commission on Carbon Prices. 2017. Report of the High-Level Commission on Carbon Prices. Washington, DC: World Bank. License: Creative Commons Attribution CC BY 3.0 IGO

[37] Horstman, E, Ayón, J, and Griscom, H (2018). Growth, survival, carbon rates for some dry tropical forest trees used in enrichment planting in the Cerro Blanco protected forest on the Ecuadorian coast. *Journal of Sustainable Forestry*, 37(2), 82-96.

[38] Crouzeilles, R, Ferreira, MS, Chazdon, RL, Lindenmayer, DB, Sansevero, JB, Monteiro, L, Iribarrem, A, Lataweic, AE, and Strassburg, BB (2017). Ecological restoration success is higher for natural regeneration than for active restoration in tropical forests. *Science Advances*, 3(11), e1701345

[39] Crouzeilles, R, Beyer, HL, Monteiro, LM, Feltran-Barbieri, R, Pessôa, AC, Barros, FS, Lindenmayer, DB, Lino, EDSM, Grelle, CEV, Chazdon, RL, Matsumoto, M, Rosa, M, Lataweic, AE, and Strassburg, BB (2020). Achieving cost-effective landscape-scale forest restoration through targeted natural regeneration. *Conservation Letters*, 13(3) e12709.

[40] Ding, H, Faruqi, S, Wu, A, Altamirano, JC, Anchondo Ortega, A, Zamora-Cristales, R, Chazdon, R, Vergara, W and Verdone, M (2017). Roots of prosperity: The economics and finance of restoring land. Washington, D.C.: World Resources Institute.

[41] Molin, PG, Chazdon, R, Ferraz, SFB, and Brancalion, PHS (2018). A landscape approach for cost-effective large-scale forest restoration. *Journal of Applied Ecology*. 55(6), 2767-2778

[42] Davenport, TRB, Machaga, SJ, Mpunga, NE, Kimiti, SP, Mwalwengele, W, Mwaipungu, O and Makumbule, PM (2022). A Reassessment of the Population Size, Demography, and Status of Tanzania's Endemic Kipunji Rungwecebus kipunji 13 Years on: Demonstrating Conservation Success. *International Journal of Primatology*, 43, 317-338